STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
A. M. SHELTON, *Director*

DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, *Chief*

REPORT OF INVESTIGATIONS NO. 7

# FURTHER CONTRIBUTIONS TO THE GEOLOGY OF THE ALLENDALE OIL FIELD, WITH A REVISED STRUCTURE MAP

BY

GAIL F. MOULTON



PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS
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38572—3M

# Further Contributions to the Geology of the Allendale Oil Field, with a Revised Structure Map

By Gail F. Moulton

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## OUTLINE



## ILLUSTRATIONS

## TABLES

# INTRODUCTION

## General Statement

The Allendale oil field is composed of several scattered pools in Wabash County in the vicinity of Allendale. During the past year, development has resulted in extensions of the old pool and it is probable that intelligent prospecting may reveal additional small pools. With a view to lending all assistance possible based on the results of a recent investigation by the Illinois State Geological Survey, this report is made available for use in further prospecting in this area. It is the purpose of the report, therefore, to give a revised interpretation of the geologic structure based on the data derived from recent drilling, thereby indicating certain areas in which further drilling is justified; to point out certain precautions that should be taken to avoid drilling some wells which would be dry because of sand conditions; and to give some of the preliminary results of the investigation of the oil field waters in this territory.

## Topography and Culture

The Wabash County region is in general gently rolling with few steep slopes except in the eastern part near Wabash River. It is drained by a

Fig. 1. The Schick lease in sec. 5, T. 1 N., R. 12 W. (Wabash Twp.), west of Allendale showing topography typical of the Allendale oil field.

system of creeks tributary to the Wabash. Graded roads are fairly numerous and make the area accessible except in the rainy season. The typical topography of the oil fields is shown in figure 1.

Mt. Carmel, the county seat, Allendale, and Friendsville are the principal towns of Wabash County. Most of the oil pools are located near Allendale, from which equipment and supplies are sent out. The region is served by the Cleveland, Cincinnati, Chicago, and St. Louis Railroad.

## History of Development

The first producing well in the Allendale field was drilled in 1912 on the Adam Biehl farm in the NE. cor. of the SE. ¼ sec. 4, T. 1 N., R. 12 W. (Wabash Township). This well obtained an initial production of 650 barrels

from a sand at about 1400 feet and started a period of intensive drilling which resulted in the development of a producing area about 1½ miles long and three-quarters of a mile wide, lying mainly in secs. 4 and 9, T. 1 N., R. 12 W. (Wabash Township).

For several years after the close of the aggressive drilling campaign early in 1913, only a small amount of drilling was done in Wabash County until the discovery, in 1922, of a flowing well on the Della Wright farm in sec. 8, T. 1 N., R. 12 W. (fig. 2). Since then, an active drilling program has resulted in the development of local pools in sec. 8, along the common section line between secs. 15 and 22, in sec. 18, and in secs. 23 and 24 of T. 1 N., R. 12 W. (Friendsville and Wabash townships), all of which are indicated in Plate I.

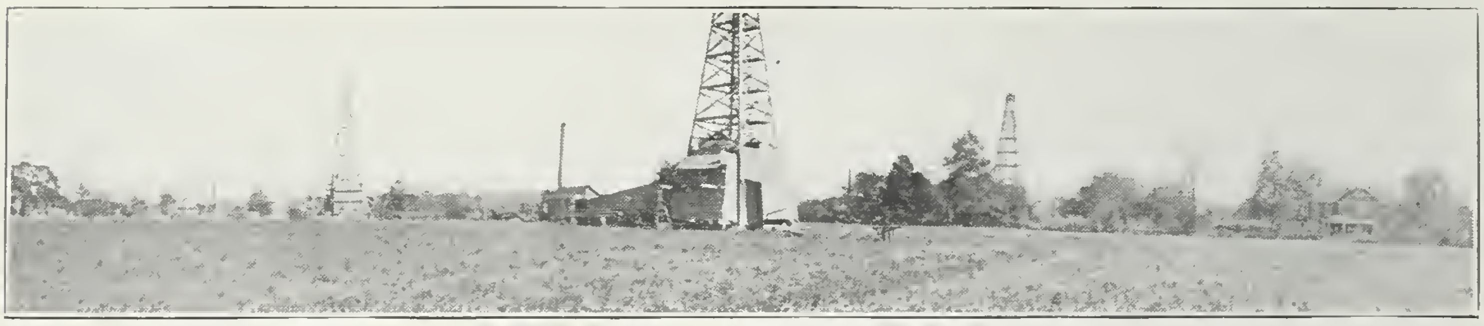

FIG. 2. The Della Wright lease in sec. 8, T. 1 N., R. 12 W. (Wabash Twp.), west of Allendale. The rig in the foreground is that of the Della Wright No. 2 well, drilled following the discovery well of 1922.

During the early drilling of this latest development, 26 dry holes and 18 producers were obtained. In 1924, 56 tests were drilled, of which 40 were producing wells with an average initial production of 85 barrels. During the first half of 1925, there has been a considerable increase in the percentage of dry holes.

### ACKNOWLEDGMENTS

Previous reports on the Allendale area have been prepared by Dr. J. L. Rich,[1] and Mr. D. M. Collingwood,[2] from which material has been freely used in the preparation of this paper and is gratefully acknowledged.

During 1924 and 1925 the author was assisted by Mr. C. R. Clark, who collected field data, and studied well cutting samples in the laboratory. The operators in the field gave generous cooperation in the matter of keeping careful logs, and saving well cuttings and water samples, with the result that much valuable information has been obtained for use in interpreting the stratigraphy and structure of the region. Particular thanks are due Messrs.

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[1] Rich, John L., Allendale oil field: Ill. State Geol. Survey Bull. 31, pp. 57-68, 1914. Rich, John L., Oil and gas in the Vincennes quadrangle: Ill. State Geol. Survey Bull. 33, pp. 147-175, 1916.

[2] Collingwood, D. M., Extension of the Allendale oil field: Ill. State Geol. Survey Press Bulletin, May 17, 1924.

J. W. Whiteside, Joe Young, Jr., Hartman and Parriot, Leavitt Gray, George Whiston, Charles Bement, Bill Kerns, Charles Blosser, E. G. Kendall, McColpin Brothers, and many other operators and drillers for their help in giving information.

# GEOLOGY

## Stratigraphy

### UNCONSOLIDATED DEPOSITS

The area is covered generally by unconsolidated deposits varying from 10 to 100 feet in thickness, composed of sands, gravels, and pebbly clays of glacial origin, and of fine yellow silt or "loess" which is the result of wind deposition. Due to the fact that these materials were brought into the region long after the folding which formed structures suitable for oil accumulation, the character of the surface and the surface deposits have no relation to conditions which determine the accumulation of oil and gas.

### CONSOLIDATED ROCKS

The consolidated rocks of the region which have been reached in drilling belong to the Pennsylvanian and Mississippian systems. The rocks of the Pennsylvanian system, about 1300 feet in thickness, overlie the rocks of the Mississippian system. Nearly all of the wells drilled pass through the Pennsylvanian strata and enter the Mississippian rocks, but no well has been reported to have penetrated all of the beds of the Mississippian system in Wabash County.

#### PENNSYLVANIAN SYSTEM

The rocks of the Pennsylvanian system consist mainly of shales and sandstones interbedded with a few thin beds of limestone. There are at least two zones at which coal is likely to be found. The sandstones are most common in the upper and lower parts of the system; the middle portion is dominantly shale. Both sandstone and shale beds, as much as 200 feet in thickness, are reported in many of the well records.

The three formations of the Pennsylvanian system which have been generally recognized in Illinois, namely—the Pottsville, Carbondale, and McLeansboro—are probably present in the Wabash County fields. A coal believed to be the equivalent of the Herrin (No. 6) coal of central Illinois is found at depths varying from 650 to 750 feet. On the basis of this correlation, the beds of consolidated rocks above that coal are placed in the McLeansboro group.

The Carbondale and Pottsville formations constitute the middle and lowest portions of the Pennsylvanian system, respectively. However, these groups cannot be separated readily in this region, because of the uncertainty in determining the horizon of the No. 2 coal which lies at the bottom of the

Carbondale formation. The lower thick sand, known to the drillers as the "Buchanan" is probably the equivalent of the beds which have been called Pottsville in other parts of Illinois. This sand is present generally, but where it is absent or very thin, the contact between the Pennsylvanian and underlying Mississippian is placed at the top of the uppermost important limestone.

MISSISSIPPIAN SYSTEM

*Chester series* (*Upper Mississippian subsystem*).—The Chester series is the uppermost part of the Mississippian system. Very few of the wells in this area have been drilled through it, although the wells in Lawrence County to the north which produce from the McClosky sand enter the lower part of the Mississippian system. Some of the distinguishing features of the Chester rocks, as compared with the Pennsylvanian, are the greater importance of limestones, the occurrence of thinner beds of sand, and a general absence of coal. This is clearly shown by a comparison of the graphic well logs in Plate II.

Apparently there was some folding and erosion of the Chester beds before the deposition of the Pennsylvanian beds and, as a result, formations of the Chester series including the oil sand are found to underlie the Pennsylvanian beds at variable depths from the Pennsylvanian contact. Such variations in depth amount to 100 feet or more in the Wabash County area. This relation is shown in Plate II.

The character of some of the Chester beds below the producing horizon is known from the logs of a few of the deeper wells. Of these, the log of the well on the Otis Matheny farm in the NE. cor. SW. ¼ sec. 18, T. 1 N., R. 12 W. (Friendsville Township) is known to be dependable. Samples for much of the deeper portion of this well were examined to obtain information in addition to the driller's log. A preliminary correlation of the Chester beds in Wabash County with the standard Chester section of Weller[3] is indicated in the composite log graphically shown on Plate I. According to the present interpretation, the producing sands of the Chester in Wabash County are equivalent to the Palestine sand of the standard Chester section in Hardin County. Since this correlation depends upon the assumption that the red beds found at a depth of 2033 feet in the Matheny well represent the Paint Creek formation, it is possible that some revision may be required later.

*Lower Mississippian subsystem.*—The rocks of the Lower Mississippian system have not been penetrated in recent drilling in Wabash County. Probably they consist largely of limestone. The upper part, or Ste. Genevieve limestone, has been found to contain porous zones which produce oil in

[3] Weller, Stuart, The geology of Hardin County and the adjoining parts of Pope County: Ill. State Geol. Survey Bull. 41, 1920.

Lawrence County and these same beds probably extend into Wabash County, although the porous condition may not persist.

PRODUCING HORIZONS

Three horizons known as the Bridgeport, Biehl, and Jordan sands, all of which are producing oil with comparatively small amounts of gas, have been developed in Wabash County.

*Bridgeport sand.*—The Bridgeport sand is of Pennsylvanian age and is found at depths varying from 1000 to 1100 feet. During the early development of the Allendale field, water commonly was found in this sand. As development extended south and east into secs. 15, 23, and 24, T. 1 N., R. 12 W. (Wabash Township), the Bridgeport sand was found to be more irregular, but small showings of oil were reported from it in some of the wells. The first producing well from this horizon in Wabash County was drilled in 1924 in the SE. cor. of the NE. ¼ sec. 23, T. 1 N., R. 12 W. (Wabash Township). Two other wells from this horizon have since been completed.

It is believed that in the part of the area developed first, the Bridgeport sand is so open to fluid circulation that the slight folding to which it has been subjected is not sufficient to trap the oil or gas. The variations in sand character in the producing area assist in causing accumulation of oil, because they here restrict the possibilities of fluid circulation. In the present producing area, the Bridgeport sand is composed of fine angular grains loosely cemented by a tan dolomitic material. The production is found principally in the upper part of the sand and approximately half of the fluid pumped is salt water.

*Biehl and Jordan sands.*—The Biehl and Jordan sands occur in the same general sand zone of the Chester, and are very irregular in thickness, character, and occurrence. Where both sands are present, they are recognized by a parting of shale which may be as much as 6 to 8 feet thick. It seems probable, however, that in some places, the shale parting may be absent, resulting in an apparent abnormal thickness of the sand, such as the 58-foot sand reported in the Della Wright well No. 7 in the NE. cor. NW. ¼, SE. ¼ sec. 8, T. 1 N., R. 12 W. (Wabash Township). The name Biehl is generally applied to the producing horizon in this area, because the Biehl and Jordan have similar characteristics and differentiation is not always possible. Both sands, therefore, will be described as the Biehl sand.

The Biehl sand is characterized by very abrupt changes in size of material and conditions of cementation with the result that the development of the field has been rather irregular and uncertain. The sand in some places is very coarse and loosely cemented; pebbles nearly one-fourth inch in diameter have come from the wells on the Wright farm in sec. 8, T. 1 N., R. 12 W. (Wabash Township). In nearby wells, the sand was found to be

so tight and fine that it produced neither oil nor water. Lateral changes from soft productive sand to dense cemented siltstone, recorded as lime by most drillers, are very abrupt. Plate III showing the details of the producing zone in some of the wells in secs. 22, 23, and 24, T. 1 N., R. 12 W. (Wabash Township), includes an area in which several of these abrupt changes occur. In sec. 22, T. 1 N., R. 12 W., there is considerable thinning of the sand between well No. 4 and well No. 5 of the Smith lease. The Leek well No. 2 found only a thin sandy zone. Other such changes take place both east and west of the Price farm in sec. 22, west of the Price farm in sec. 23, and near the west quarter corner of sec. 24, T. 1 N., R. 12 W. The section (Pl. III) shows that the top of the sand zone is fairly regular, but that the thinning is due mostly to a rise in the surface on which the sand was deposited.

Available information is believed to indicate that the Biehl sand was deposited in the distributary channels of a stream discharging into the sea. These channels were rather crooked and winding, and apparently branched in a southerly direction. When active currents in them were gradually slowed up, they deposited the coarser sand but carried the fine particles into more quiet water. Apparently the time of sand deposition was followed by a condition of weaker currents, because the last phase of deposition resulted in a fine grained siltstone which is the present cap-rock and extends over a much larger area than does the sand. Although the information now obtainable is not sufficient to permit a definite conclusion regarding the conditions of deposition of the Biehl sand, this hypothesis seems to be consistent with all of the observed phenomena.

It is obvious that serious difficulties attend an effort to predict the trend or occurrence of a sand body deposited under the conditions outlined, but some information in advance of drilling should be obtainable from the data regarding nearby wells. By constructing cross-sections of the producing zone similar to Plate III and by making measurements of the size of grain, it should be possible to determine the direction in which the sand becomes thinner and finer, once a few wells have been drilled in any given locality. It will probably not be possible to predict the failure of the sand under other conditions, but elimination of even a few of the dry holes will compensate many times for the additional trouble of keeping careful samples and exact logs.

As a result of a study of the size and shape of sand grains in the laboratory, it was found that in many places there was a gradual reduction in the size of grain in the coarsest part of the sand and also a thinning of the coarse part of the Biehl zone toward the non-productive areas. Some of the recommendations for further drilling, which are given later, are based on interpretations of local conditions by use of this information.

## Structural Geology

Wabash County lies to the southwest of the main producing fields of Lawrence County. In general, the dips are rather gentle and average about 40 feet per mile. Stronger west dips have been determined a few miles southeast of Lancaster, located in sec. 4, T. 2 N., R. 13 W. The principal features of the structure are the general west dip which is interrupted by several slight anticlinal folds along which a series of small irregular domes have been developed. These anticlinal structures are indicated on the map (Pl. I) by means of contours drawn on the top of the cap-rock of the Biehl sand.

The principal fold of the county as shown in Plate I trends practically north-south in the area north of Allendale, and seems to divide into three separate folds near Allendale; one with a trend slightly west of south which goes through Mt. Carmel; the second to the east through sec. 18, T. 1 N., R. 11 W., and the third with a trend slightly east of south which crosses Wabash River into Indiana. A minor fold is located west of Allendale and includes the principal producing area. Structural cross-sections are given in Plates II and IV. It should be observed that in these graphic representations correlations of sand with lime are made for the Biehl. This is probably correct, as the siltstone phase of the Biehl is almost invariably logged as lime by the drillers.

The contour lines on the structure map (Pl. I) show the elevation of the top of the cap-rock of the Biehl sand in feet below sea level. Further drilling may reveal discrepancies in portions of the map in which data are not sufficiently reliable to permit actual structural representation at this time. Revision of the map, based on later drilling data, should be considered in determining the possible existence of other structures favorable for oil accumulation.

## Oil and Gas Accumulation

The accumulation of oil and gas in the Allendale field is governed by a combination of structural and sand conditions. The importance of locating a well on a high structural dome is clearly shown on the Jake Smith lease in sec. 22, T. 1 N., R. 12 W. (Wabash Township). Well No. 1 struck the sand rather low on the west side of the dome with the result that a large amount of water has been produced with the oil. The later wells were located higher on the dome and little water trouble was experienced. In contrast, well No. 1 on the Leek farm, was located about a quarter of a mile south and considerably down the dip from the good wells, with the result that water without a showing of oil was obtained.

Sand conditions are likewise of great importance in getting oil production. The total pore space in the sandy body limits the amount of oil present,

and the size of the grains determines the rate of production under uniform conditions of sand thickness, sorting, and cementation, and of oil character, pressure, and temperature. The photographs of the grains of sand from a big producer (fig. 3), a small producer (fig. 4), and of the grains of siltstone in the non-productive cap-rock (fig. 5), serve to illustrate the variation which may occur. As the conditions under which the fine grains accumulated

Fig. 3. Photograph of grains of coarse sand from a large producer. 25 × natural size.

seem to have been favorable for extensive cementation, the effect of the variation in size of grains in controlling production is increased.

Coarse bodies of sand of limited extent are desirable reservoirs for two reasons. In the first place, they give a larger initial production than fine sand does under similar conditions, for under uniform conditions with sorted grains, the flow capacity increases in proportion to the square of the diameter

of the grains.[4] Accordingly, if the size of grains is doubled, the rate of flow is four times as great. In the second place, coarse sands generally insure the recovery of a larger fraction of the oil because of the free flow from all parts of the sand body to the well. Very free communication of fluid pressure through the open coarse sands has been shown several times by the effect of a newly completed well on the production of a nearby older one. After

FIG. 4. Photograph of grains of fine sand from a small producer. 25 × natural size.

the second well on the Della Wright lease in sec. 8, T. 1 N., R. 12 W. (Wabash Township) had been completed, the production of the first well dropped so abruptly that the combined production of the two wells was only about one and a half times as great as that of the first well alone. Well No. 2

[4] King, F. H., Movements of ground water: 19th Ann. Rept. U. S. Geol. Survey, Pt. II, p. 241, 1898.

on the Price farm in sec. 22, T. 1 N., R. 12 W .(Wabash Township) had a similar effect on well No. 1, and the W. F. Courter well in sec. 24, T. 1 N., R. 12 W. caused a very marked drop in the production of the Winters No. 1 well nearby. Open sands of this character apparently favor a high per cent recovery.

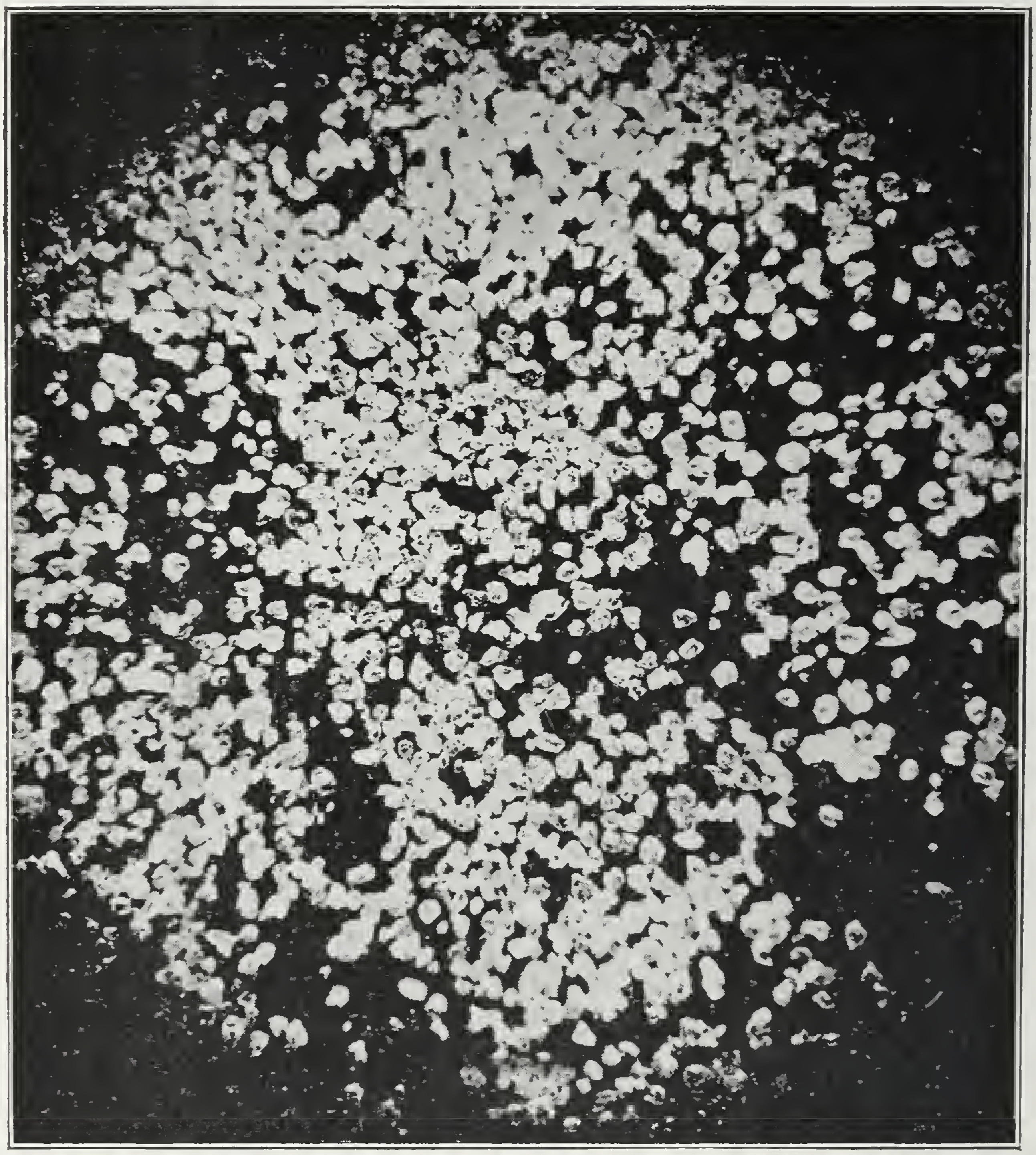

Fig. 5. Photograph of grains of siltstone cap rock. 25 × natural size.

## Plan for Systematic Prospecting

Since both structural conditions and local sand conditions must be favorable in order to bring about oil accumulation, the obvious procedure in prospecting is to find a suitable structure, and then to test various parts of it to find the proper type of sand. The variation in the character of the water and the disappearance of the sand, locally, indicate that the sand bodies do not have connection permitting the ready flow of oil and water. Under

these conditions, oil will be found in the highest part of each of the sand lenses.

If a sand lens crosses an anticlinal axis, the place of intersection is the highest point for the sand in that locality. Therefore, prospecting to find a sand lens can be best undertaken along what has been determined as the anticlinal axis or crest. Figure 6 indicates the significance of the various possible results of drilling relative to the structure and to the location of the productive zone. If the first well found no sand, it would probably be best to move a short distance down the dip of the anticlinal axis, as in well No. 1 in figure 6. If the first well found water with no oil, as in well No. 2, the next well should be drilled a considerable distance up the dip. If the first well found both water and oil in the sand, the lower part of the sand should be cemented and the next well should be drilled up the dip at least one location. If the first well found oil, further drilling should be done nearby, and both the structure and the change in character of the sand lenses carefully observed and used as a guide in the location of further tests. If the first well found a fine sand with only a show of oil, as in well No. 5 in figure 6, the logical move would be to drill lower on the axis of the fold a short distance from the first test.

## Localities for Future Prospecting

Several favorable areas in the Allendale region remain inadequately tested. One of the most promising of these is the plunging anticline which extends across the southeastern part of sec. 36, T. 2 N., R. 12 W., and the northwestern part of sec. 1, T. 1 N., R. 12 W., immediately north of Allendale.[5] The Biehl sand found in the Compton well in the NW. ¼ sec. 12, T. 1 N., R. 12 W., was very open and suitable for giving a large production. If this sand contains oil farther north on the structure and does not change much in character, large wells could be expected. Further prospecting according to the plan outlined is deserved in this area, which is designated as No. 1 in Plate I.

A second area for further prospecting is the plunging anticline east of Patton, which is located in sec. 33, T. 1 N., R. 12 W., indicated in Plate I as shaded area No. 2. This anticline seems to be fairly well defined and although it has not been productive in the southern part where tested, there is probably considerable chance of finding production here.

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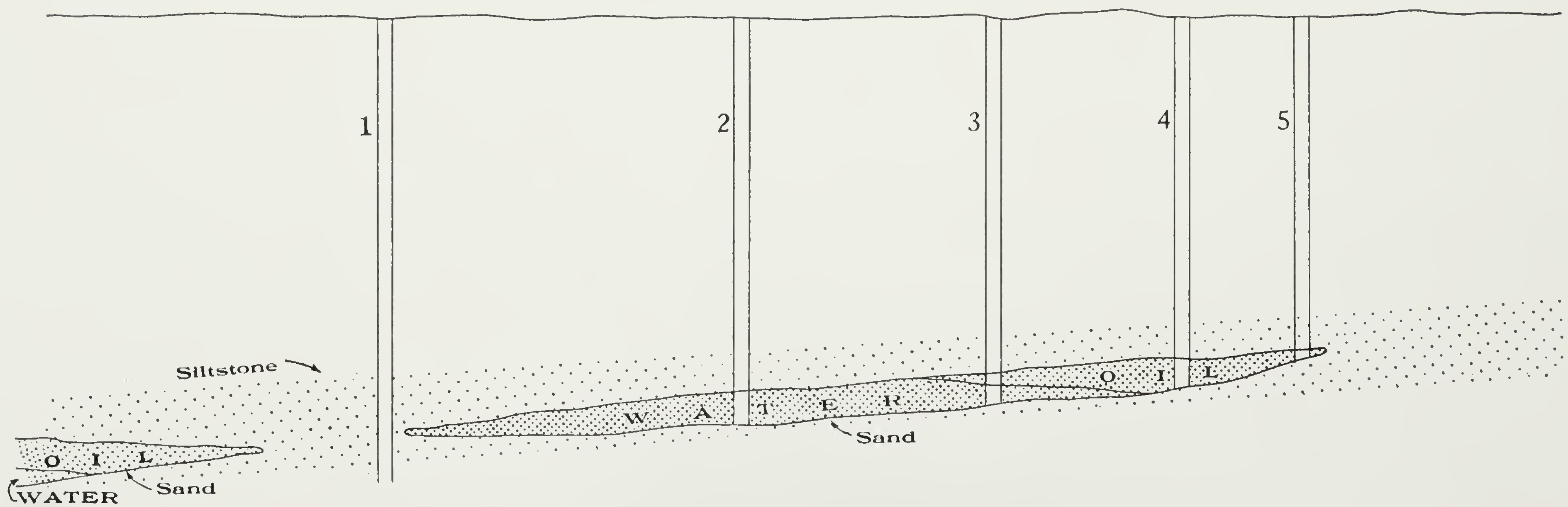
[5] During the time that this report was in press, area No. 1 (Pl. I) first recommended by D. M. Collingwood in the State Geological Survey Press bulletin in 1924, was tested. The first well was drilled on the Price farm in sec. 36, T. 2 N., R. 12 W. and gave only a very small production because of the dense character of the sand found there. The second well was drilled on the S. J. Stillwell farm in the NW. ¼ SE. ¼ sec. 1, T. 1 N., R. 12 W. and produced more than 500 barrels a day. New drilling was greatly stimulated by this discovery. Later wells were obtained in the vicinity, but many of them were smaller than the first well. Present drilling will test other parts of the favorable area so that during the next few months the producing area which can be expected should be well defined.




1. Missed sand.
2. Sand contains water.
3. Sand contains water and oil.
4. Sand contains oil. Good producer.
5. Fine sand. Small oil production.

FIG. 6. Diagram to illustrate distribution of oil and water in a sand lens and to indicate the significance of results of drilling.

A third area to be tested further is located along the anticline which crosses parts of secs. 17, 18, 19, and 30, T. 1 N., R. 12 W., and sec. 24, T. 1 N., R. 13 W., a short distance east of Friendsville, indicated on Plate I as shaded area No. 3. The presence of anticlinal structure is not so definitely established as in the other areas described, but unless the logs of three wells located in the structural depression shown east of area No. 3 (Pl. I) have been incorrectly interpreted, there is structure favorable for the accumulation of oil within this area. Because of the slight uncertainty in the interpretation, the first wells drilled should be used as a careful check of the structural conditions before proceeding with a complete program of testing.

There is some prospect of finding production in some of the deeper sands. The deep well on the Otis Matheny farm in the NW. ¼, SW. ¼ sec. 18, T. 1 N., R. 12 W. (Friendsville Township) struck several sands below the Biehl sand which might produce oil in wells located on more favorable parts of the structure. Before hope of deeper production is abandoned entirely, deep tests to the Ste. Genevieve lime should be drilled on the high parts of the local producing domes. It seems entirely probable that a test well might find production in a deeper sand in this area, because they have not yet been tested on favorable structures in Wabash County and deep sands have been found to be productive in Lawrence County.

In addition to the areas which have been recommended for further testing on a basis of structural conditions, two other smaller areas are suggested as a result of sand examinations and from a consideration of the conditions of sand deposition stated earlier in the report. One of these is northeast of the Robinson No. 1 well in the NW. cor. SW. ¼ of SE. ¼ sec. 15, T. 1 N., R. 12 W. It will probably be advisable to locate a test well east and a short distance north of that well. The other area recommended for further prospecting, as indicated by the information at hand, is located northeast of the Armstrong No. 1 well in the NW. ¼ SE. ¼ sec. 24, T. 1 N., R. 12 W. Probably one test should be drilled in that direction to determine conditions there.

## OIL FIELD WATER INVESTIGATIONS

The first systematic investigation of the geochemical relations of the ground waters in the oil fields of Wabash County was begun during the summer of 1924 and is still under way. The State Water Survey has cooperated with the State Geological Survey by furnishing water containers and making the mineral analyses of the water samples sent in. At the present time it seems desirable to make a preliminary statement of results and to mention a few of the problems which are being considered.

## General Results

Two general changes in water character which may be of assistance later in using waters for the purpose of correlation have been observed. First, there is a somewhat progressive increase in salinity with increase in depth of the sand from which the water comes. Although there is considerable local variation in different samples of water reported to come from the same sand, the change in waters from different depths is much more pronounced. These effects can be seen by a comparison of the salinity shown in the graphic representation of the analyses (figs. 7 to 12).

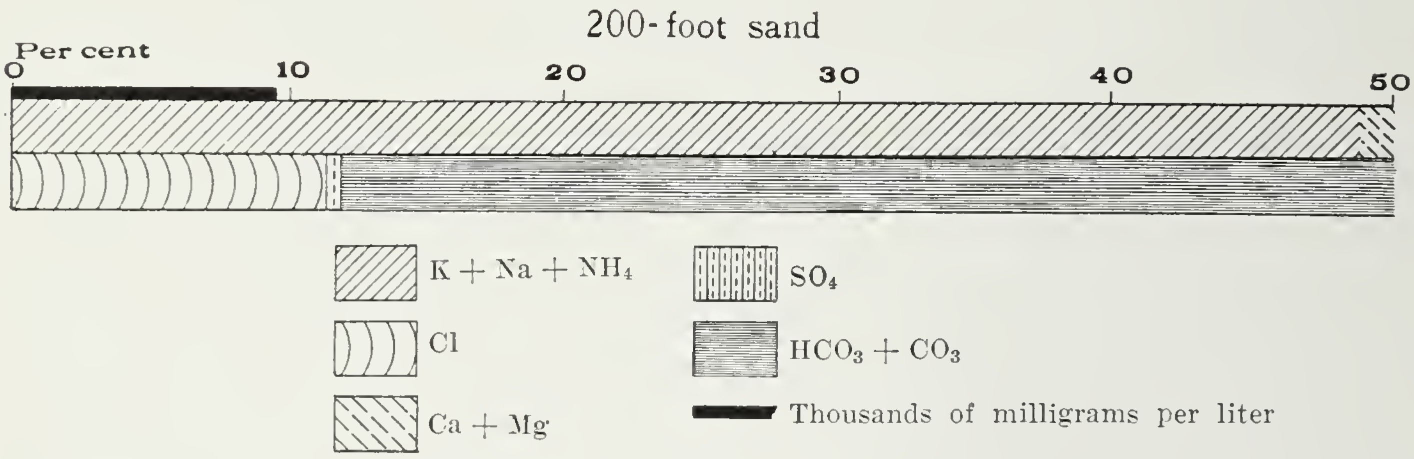



Fig. 7. Graphic analysis of water sample from fresh water sand at a depth of 200 feet in the D. Wright water well in the SE. cor. NW. ¼ SE. ¼ sec. 8, T. 1 N., R. 12 W. (Laboratory No. 51946.)

A second change in water character with depth which seems to be fairly consistent is the decrease in carbonate-bicarbonate content in the deeper waters. The contrast is greatest between the waters at great depth and those near the surface, but even in comparing different waters from deeper horizons it can be observed to a slight extent.

## Expression of Analyses

Because of the fact that equal weights of two reacting substances would not satisfy the ability of both to react, the weights as determined in analysis which have been recalculated to equivalent amounts, or combining amounts. These new numbers represent weights such that any certain combining amount of one substance will completely neutralize the same numerical combining amount of any other. In this way, much confusion will be avoided which might otherwise be introduced, due to the difficulty in a proper comparison of the actual weights of the different chemical radicals.

Further difficulties are introduced by the variation of the concentration of the brine to be considered. For most purposes, it is essential to be able to recognize the quality of a water as well as to know how concentrated a

solution it is. Accordingly, the final form of each analysis shows the percentage of reacting value of each chemical radical which is present in the solute, or salts in solution, and the amount of solute in the solution.

The complete data computed from the analyses is given for typical water samples from the Buchanan and Biehl sands. The analyses show the relation of the various substances present in terms of milligrams per liter and per cent reacting value.

TABLE 1.—*Analysis of typical water sample from the Buchanan sand, Winters No. 1 well in the NW. ¼ SE. ¼ sec. 24, T. 1 N., R. 12 W., Wabash County*

| *Constituents in milligrams per liter* | | *Hypothetical combinations* | |
|---|---|---|---|
| Na | 11570. | $KNO_3$ | .8 |
| K | 679.2 | KCl | 1288.3 |
| Ca | 638.9 | NaCl | 25883. |
| Mg | 184.8 | $Na_2SO_4$ | 4110.5 |
| Fe | 0.2 | $(NH_4)_2SO_4$ | 46.9 |
| $Al_2O_3$ | 25.7 | $MgSO_4$ | 910.0 |
| Mn | 1.4 | $CaSO_4$ | 1892.3 |
| $NH_4$ | 12.9 | $CaCO_3$ | 196.6 |
| $SO_4$ | 4856. | $Fe_2O_3$ | .3 |
| Cl | 16228. | MnO | 1.8 |
| $NO_3$ | 0.5 | $SiO_2$ | 14.0 |
| $HCO_3$ | 196. | $Al_2O_3$ | 25.7 |
| $SiO_2$ | 14. | | |
| *Total solids* | 34160. | *Total solids* | 34370.2 |

*Reacting values in per cent*

| | |
|---|---|
| Alkalies: rNa | 44.45 |
| rK | 1.53 |
| $NH_4$ | 2.06 |
| Alkaline earths: rCa | 2.98 |
| rMg | 1.33 |
| Strong acids: $rSO_4$ | 8.92 |
| rCl | 40.51 |
| $rNO_3$ | .35 |
| Weak acids: | |
| $rHCO_3$ | .35 |

Date analyzed: May 20, 1925. Lab. No. 52503.

Table 2.—*Analysis of typical water sample from the Biehl sand, Della Wright well No. 1 in the SW. ¼ SE. ¼ sec. 8. T. 1 N., R. 12 W., Wabash County*

| *Constituents in milligrams per liter* | | *Hypothetical combinations* | |
|---|---|---|---|
| Na | 15080. | $KNO_3$ | 4.0 |
| K | 2111. | KCl | 4010.0 |
| Ca | 428.5 | NaCl | 38620.0 |
| Mg | 434.8 | $NH_4Cl$ | 37.9 |
| Fe | 0.2 | $MgCl_2$ | 227.2 |
| $Al_2O_3$ | 7.7 | $MgSO_4$ | 1862.0 |
| Mn | 0.0 | $CaSO_4$ | 327.5 |
| $NH_4$ | 12.9 | $CaCO_3$ | 830.0 |
| $SO_4$ | 1718. | $Fe_2O_3$ | .2 |
| Cl | 25346. | $SiO_2$ | 18.0 |
| $NO_3$ | 2.5 | $Al_2O_3$ | 7.7 |
| $HCO_3$ | 780. | | |
| $SiO_2$ | 18. | | |
| *Total solids* | 4482. | *Total solids* | 45944.5 |

*Reacting values in per cent*

| | |
|---|---|
| Alkalies: rNa | 42.7 |
| rK | 3.51 |
| Alkaline earths: rCa | 1.40 |
| rMg | 2.3 |
| Strong acids: $rSO_4$ | 2.3 |
| rCl | 46.6 |
| Weak acids: $rHCO_3$ | 1.0 |

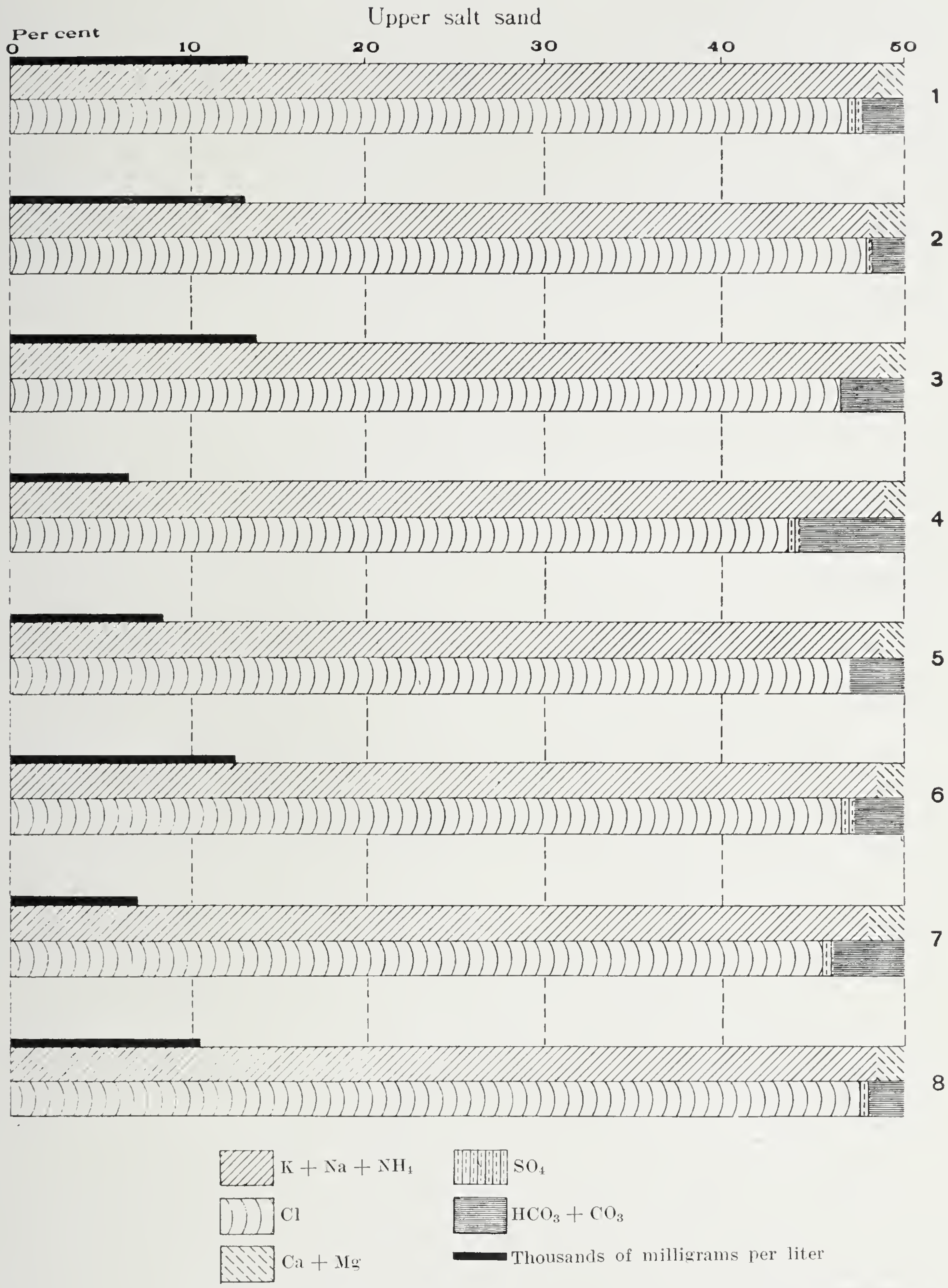
Date analyzed: April 15, 1925. Lab. No. 52259

A later more detailed report of water investigation will contain similar data for the analyses of a larger number of samples. The available water analyses of samples from the Wabash County oil fields are shown in graphic form in figures 7 to 12.

In the graphic representation of analyses, the per cent of reacting value of certain types of radicals is shown. For further convenience of comparison, the base radicals are shown in the upper column and the acid radicals in the lower column, each totaling fifty per cent. The heavy line immediately above the percentage columns indicates the amount of the mineral matter in solution in terms of grams per liter.

Certain advantages are inherent in the use of graphical representations of water analyses. In the first place, the broad relations of a large number of waters may be visualized readily. In the second place, it is possible to determine the general composition and character of the water at a glance.

The groups of graphic analyses are so arranged that the sands from which the waters were taken are the progressively deeper ones. Therefore,

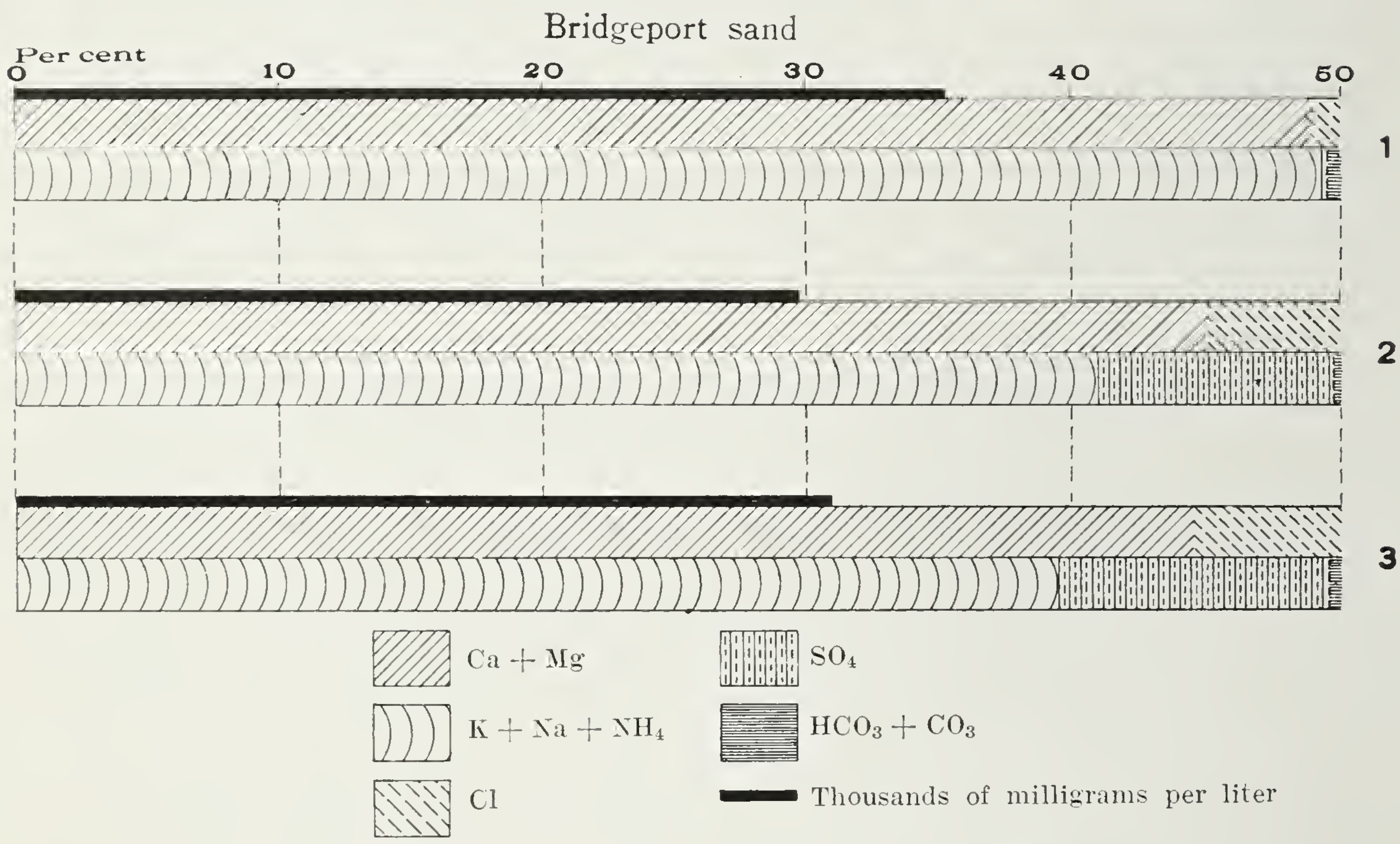



| Analysis No. | Farm name | Well No. | Section | Township | Depth to sand | Laboratory No. |
|---|---|---|---|---|---|---|
| | | | | | *Feet* | |
| 1 | A. Biehl | 2 | 15 | Wabash (T. 1 N., R. 12 W.) | 580 | 52079 |
| 2 | Leck | 2 | 22 | Wabash (T. 1 N., R. 12 W.) | 525 | 52080 |
| 3 | Rogers | 1 | 14 | Lawrence (T. 3 N., R. 12 W.) | 620 | 52045 |
| 4 | Leighty | 3 | 8 | Wabash (T. 1 N., R. 12 W.) | 691 | 52173 |
| 5 | Van Wright | 1 | 13 | Wabash (T. 1 N., R. 12 W.) | .......... | 52777 |
| 6 | Ed Wright | 1 | 15 | Wabash (T. 1 N., R. 12 W.) | 580 | 52353 |
| 7 | Clara Adams | 1 | 23 | Wabash (T. 1 N., R. 12 W.) | 650 | 52260 |
| 8 | S. Compton | 1 | 12 | Wabash (T. 1 N., R. 12 W.) | 550 | 52367 |

Fig. 8. Graphic analyses of water samples from shallow salt water sands in Wabash and Lawrence townships, Wabash County.

any changes which appear in the comparison of the analyses in successive groups are at least partly due to the increased depths.

Certain relations between the various sorts of chemical radicals are found to be of importance in distinguishing the waters from the various geologic horizons. In examining the diagrams of the percentages of reacting values, the following relations were compared: Alkalies ($K + Na + NH_4$) to chlorides ($Cl$), alkalies ($K + Na + NH_4$) to strong acids [chloride ($Cl$) plus sulphate ($SO_4$)], chlorides ($Cl$) to sulphates ($SO_4$), and sulphates ($SO_4$) to carbonates ($CO_3$) plus bicarbonates ($HCO_3$).




| Analysis No. | Farm name | Well No. | Section | Township | Depth to sand | Laboratory No. |
|---|---|---|---|---|---|---|
| | | | | | *Feet* | |
| 1 | J. T. Smith | 1 | 17 | Wabash (T. 1 N., R. 12 W.) | 973–1170 | 52017 |
| 2 | Price | 1 | 22 | Wabash (T. 1 N., R. 12 W.) | 1125 | 51908 |
| 3 | Ed Wright | 1 | 15 | Wabash (T. 1 N., R. 12 W.) | 1150 | 52368 |

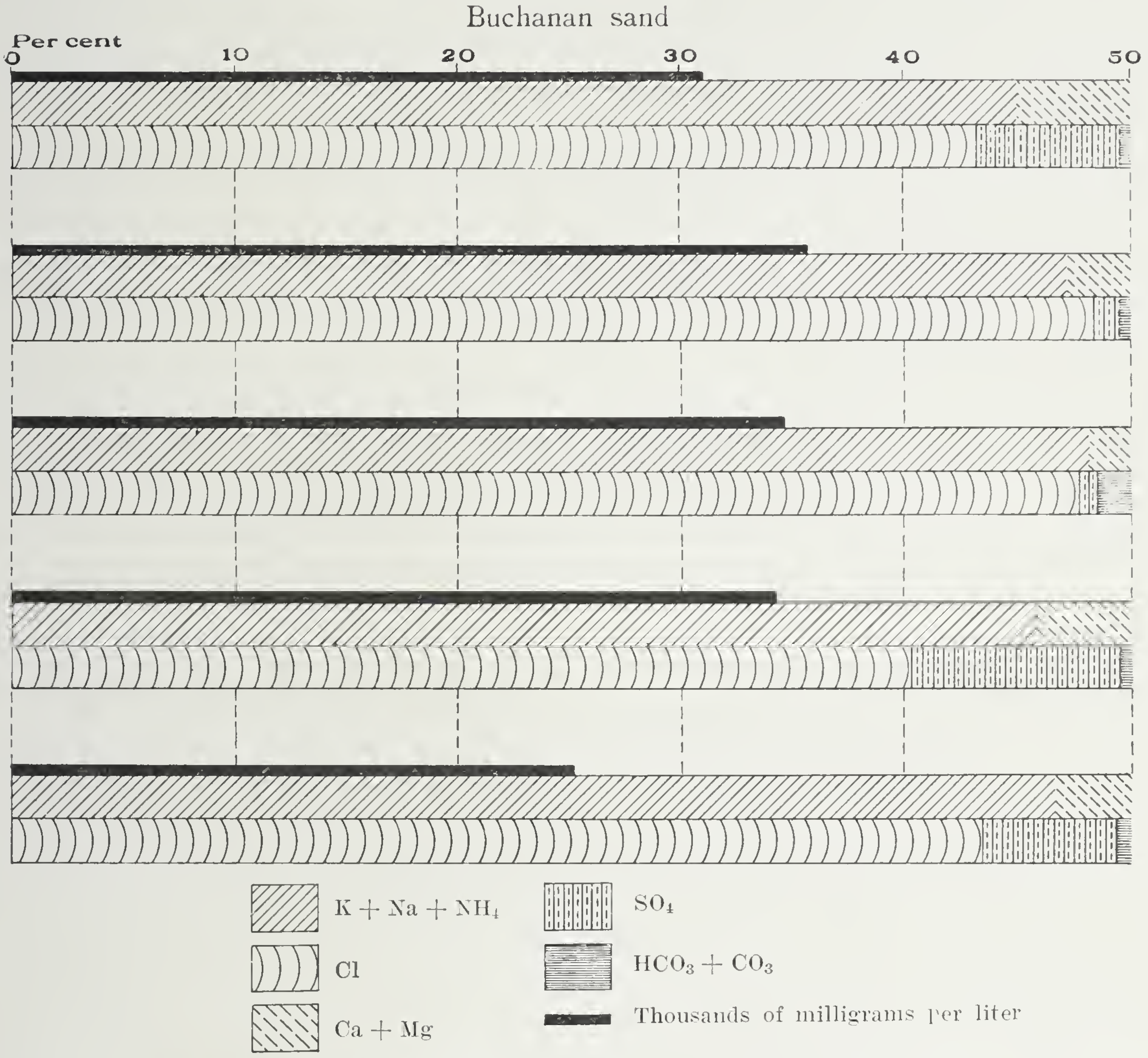
FIG. 9. Graphic analyses of water samples from the Bridgeport sand.

## COMPARISON OF WATER ANALYSES FROM VARIOUS HORIZONS

The analysis shown graphically in figure 7 represents the character of a water in a shallow sand which probably outcrops under the glacial drift within a few miles of the well from which the sample was taken. Therefore, the character of this water may be interpreted as being due to a mixture of a comparatively small amount of the original brine with a large amount of surface water. Interesting features of this water are its high alkali and carbonate percentage. The low concentration of mineral matter in this water indicates a considerable degree of dilution by surface waters.

Accordingly, the high per cent of carbonate plus bicarbonate and alkali present is considered to characterize the surface waters of the region.

The upper salt water sand contains more concentrated brines. These are represented by analyses shown graphically in figure 8. This group of




| Analysis No. | Farm name | Well No. | Section | Township | Depth to sand | Laboratory No. |
|---|---|---|---|---|---|---|
| | | | | | *Feet* | |
| 1 | Jake Smith | 5 | 22 | Wabash (T. 1 N., R. 12 W.) | 1210 | 52078 |
| 2 | Newsum | 1 | 18 | Friendsville (T. 1 N., R. 12 W.) | 1200 | 52147 |
| 3 | Holsen and Dorney | 2 | 19 | Wabash (T. 1 N., R. 11 W.) | 1410 | 52030 |
| 4 | Winter | 1 | 24 | Wabash (T. 1 N., R. 12 W.) | 1200 | 52503 |
| 5 | S. Compton | 1 | 12 | Wabash (T. 1 N., R. 11 W.) | 1280 | 52502 |

FIG. 10. Graphic analyses of water samples from the Buchanan sands.

water samples is characterized by a salinity which ranges from about 7,000 milligrams per liter to about 13,500 milligrams per liter. The alkalies are in excess of the strong acids. The amount of chloride is very considerably larger than the sulphate which in no case exceeds 1 per cent reacting value and in most of the waters is practically negligible. Carbonate plus bicarbonate is more than five times as great as sulphate and has more than 2 per cent reacting value.

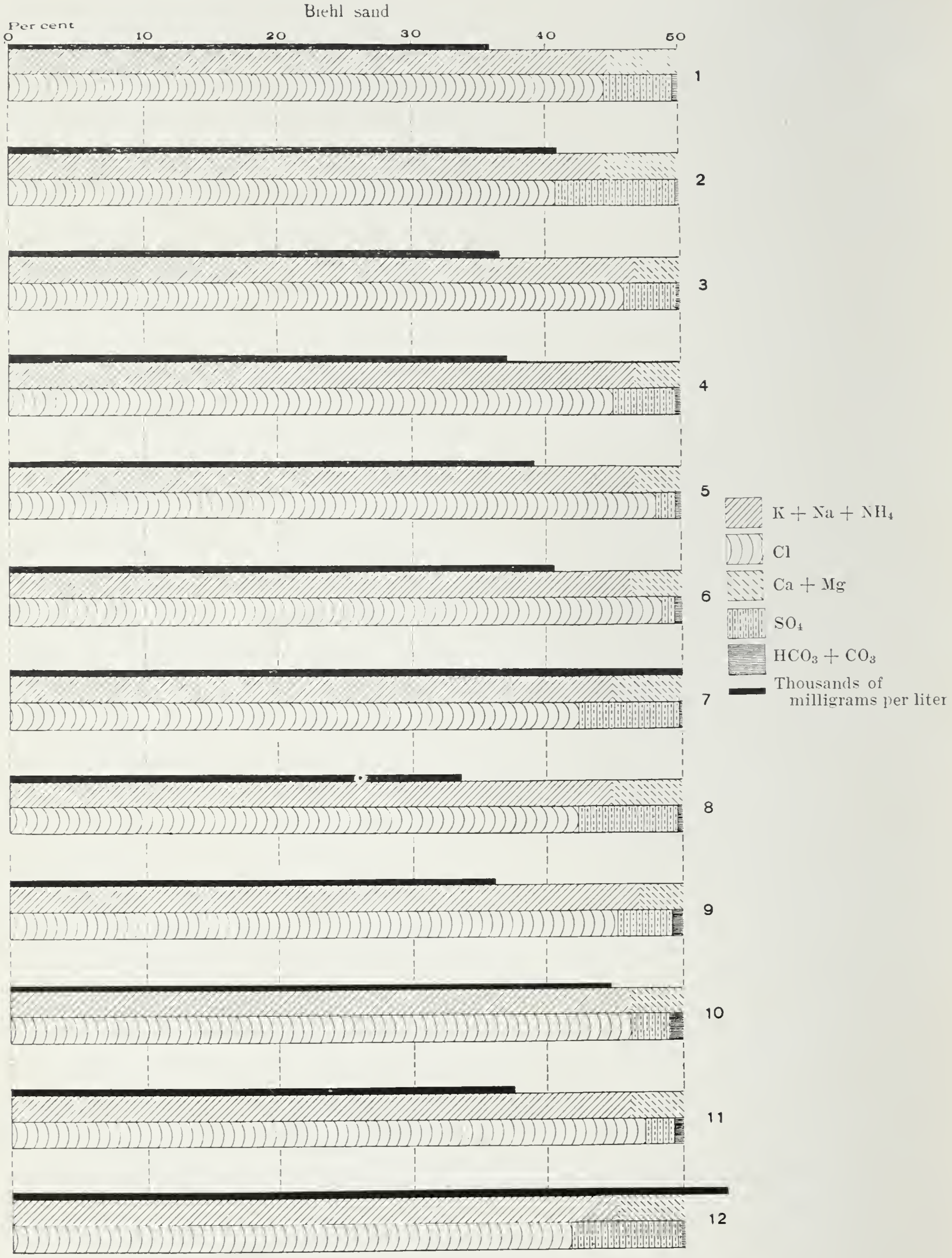



FIG. 11. Graphic analyses of water samples from the Biehl sand.

The waters of the Bridgeport sand, represented by graphic analyses in figure 9 are easily distinguished from the preceding groups on the basis of both concentration and composition. The salinity appears to average about 30,000 milligrams per liter, a marked increase from the waters above. The decrease in the importance of carbonates and bicarbonates is a very striking feature of these analyses. A general increase of sulphate in proportion to both chloride and carbonate is noticeable. In these waters, the alkalies are less than the strong acids, and the proportion of earths is greater than in the higher waters.

Graphic analyses shown in figure 10 represent samples from the Buchanan sand. The salinity in general is higher in these samples than in the ones from the higher sands, but not in all cases; it seems to average about 33,000 milligrams per liter. In general, the water from the Buchanan sand appears to contain a higher percentage of alkalies than that from the Bridgeport sand. The number of analyses is insufficient to justify a statement that diagnostic characteristics have been determined which will always differentiate these waters, for they are very similar. However, the water from the Buchanan sand, because of its higher concentration, can be distinguished from that of the sands above the Bridgeport without difficulty.

The character of the water from the Biehl sand (fig. 11) shows considerable variation. The average concentration of these waters is still higher than that of the waters in the overlying sands, appearing to be about 38,000 milligrams per liter. A larger number of analyses of waters from the Biehl sand is available than for any of the other sands. As a result of this more detailed information, it has been possible to conclude that although there is as great a variation in the composition of the waters from various parts of the field as is the case for any of the other waters, the character of the water in any particular locality is closely similar. Therefore, although the water in the Biehl sand is generally similar to water in the Buchanan sand, there should be little trouble in detecting mixed waters if the character of the water in the Biehl is known in a certain locality.

---

Legend for figure 11.

| Analysis No. | Farm name | Well No. | Section | Township | Depth | Remarks | Laboratory No. |
|---|---|---|---|---|---|---|---|
| 1 | Cozine | 1 | 16 | Wabash (T. 1 N., R. 12 W.) | 1512 | .......... | 51945 |
| 2 | Price | 1 | 22 | Wabash (T. 1 N., R. 12 W.) | 1464 | With oil | 52197 |
| 3 | A. Biehl | 1 | 15 | Wabash (T. 1 N., R. 12 W.) | ........ | With oil | 52149 |
| 4 | Jake Smith | 1 | 22 | Wabash (T. 1 N., R. 12 W.) | ........ | With oil | 52148 |
| 5 | Ed Smith | 4 | 9 | Wabash (T. 1 N., R. 12 W.) | ........ | With oil | 52370 |
| 6 | Ed Smith | 2 | 9 | Wabash (T. 1 N., R. 12 W.) | ........ | With oil | 52369 |
| 7 | M. U. Litherland | 4 | 4 | Wabash (T. 1 N., R. 12 W.) | ........ | With oil | 52266 |
| 8 | G. P. Smith | 3 | 5 | Wabash (T. 1 N., R. 12 W.) | ........ | With oil | 52267 |
| 9 | Caroline Smith | 3 | 9 | Wabash (T. 1 N., R. 12 W.) | ........ | With oil | 52354 |
| 10 | Della Wright | 1 | 8 | Wabash (T. 1 N., R. 12 W.) | ........ | With oil | 52259 |
| 11 | Caroline Smith | 1 | 9 | Wabash (T. 1 N., R. 12 W.) | ........ | With oil | 52356 |
| 12 | Lutz | 1 | 8 | Friendsville (T. 1 N., R. 12 W.) | ........ | With oil | 52265 |

A similarity of composition in waters from the Biehl sand would seem to indicate continuity of the sand between the wells sampled. If this theory is correct, the Biehl sand found in the wells on the Della Wright lease in the SE. ¼ sec. 8, T. 1 N., R. 12 W., is connected with the sand which yields the oil on the M. U. Litherland and G. D. Smith leases to the north in the S. ½ of sec. 5, T. 1 N., R. 12 W.; and not to the sand producing in the wells to the east in sec. 9, T. 1 N., R. 12 W. On that basis, further prospecting should find the sand between the Wright and Litherland leases.

Only one sample (fig. 12) has been obtained from sands below the Biehl in Wabash County. This water shows a very high salinity and a further decrease in percentage of alkalies.

Additional sampling and greater attention to detailed comparisons of analyses should result in establishing criteria which will permit the differentiation of the waters on the basis of their chemical composition and should prove very useful in determining the source of water which is not coming from an oil sand and which may be spoiling a well.

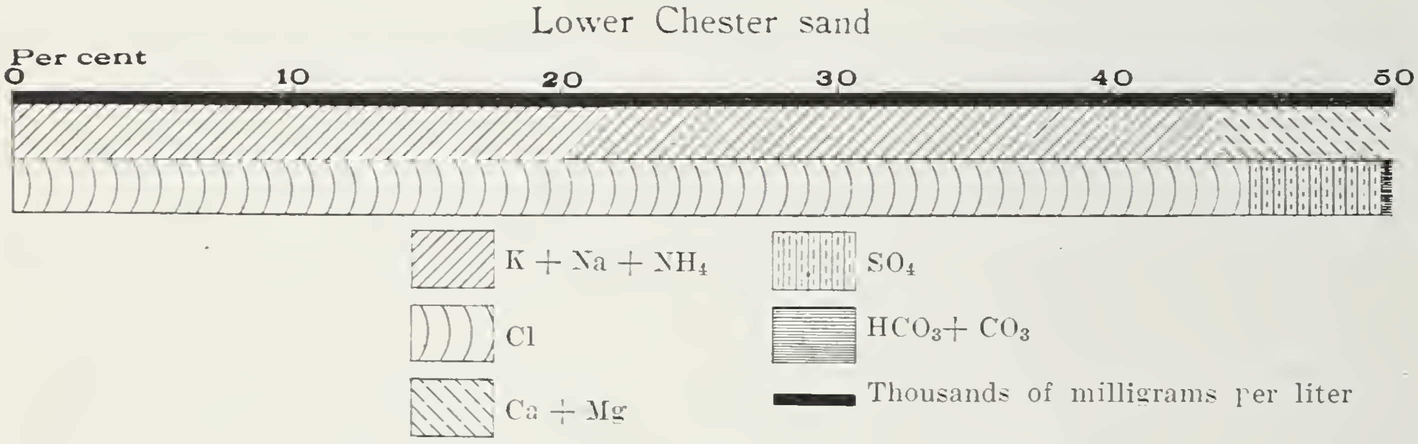



FIG. 12. Graphic analysis of water sample from deep Chester sand in the Otis Matheny No. 2 well in sec. 18, T. 1 N., R. 12 W. (Laboratory No. 52779)

It further seems possible that more detailed investigations will establish a relation between the character of the water and the structural features present. If this can be done, the water investigations will be a great aid to locating new pools. The investigation of the effect of oil on the mineral character of the water with which it has associated may possibly provide an aid in determining the relative proximity of an oil pool to a well which produces water. Other problems will probably develop during the course of the investigation.

## COOPERATION WITH THE ILLINOIS STATE GEOLOGIC SURVEY

It is the hope of the Illinois State Geological Survey that the operators of the Allendale field will continue to cooperate in the matter of keeping careful records and samples of drill cuttings as they have done in the past.

The past cooperation of the oil field operators in taking water samples also has been greatly appreciated, and it is very desirable that the cooperation be continued so that more complete, definite, and valuable conclusions can be reached. It is interesting to note that after the publication of the Press Bulletin[6] on the Allendale field, the percentage of dry holes was reduced greatly below what it had been in the preceding year. If a similar improvement in the results of drilling follows the publication of other reports, the scientific effort and financial investment made by the State will be further encouraged.

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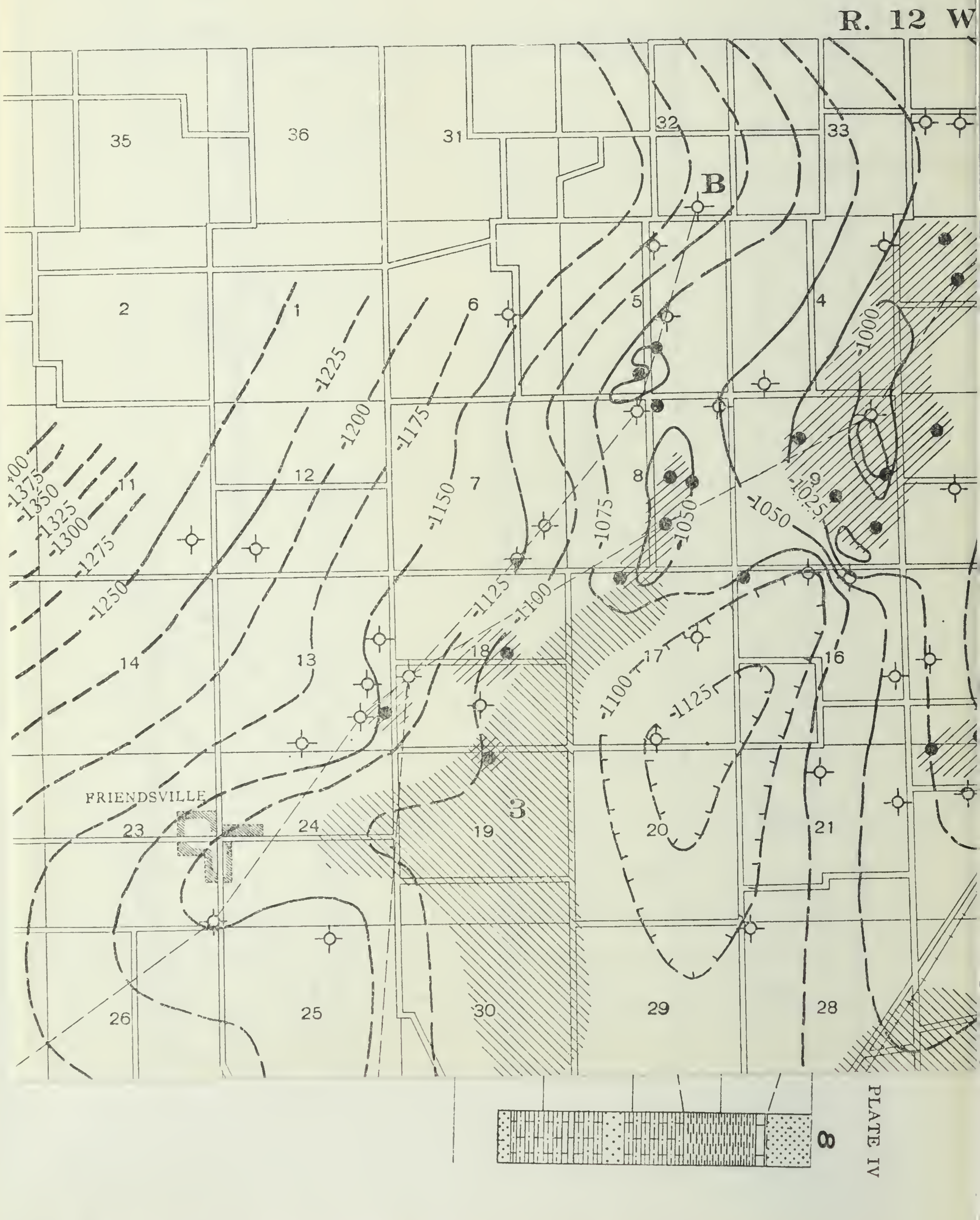
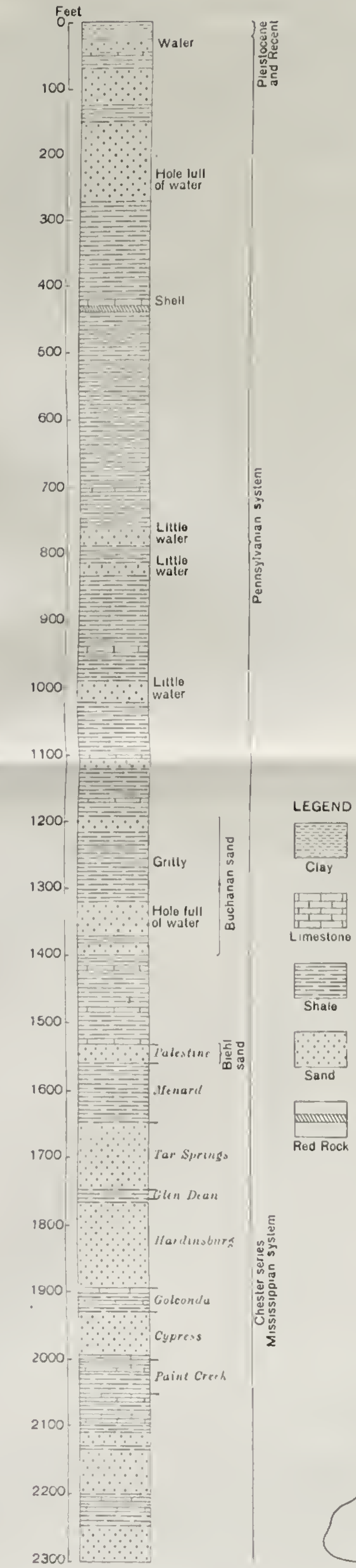
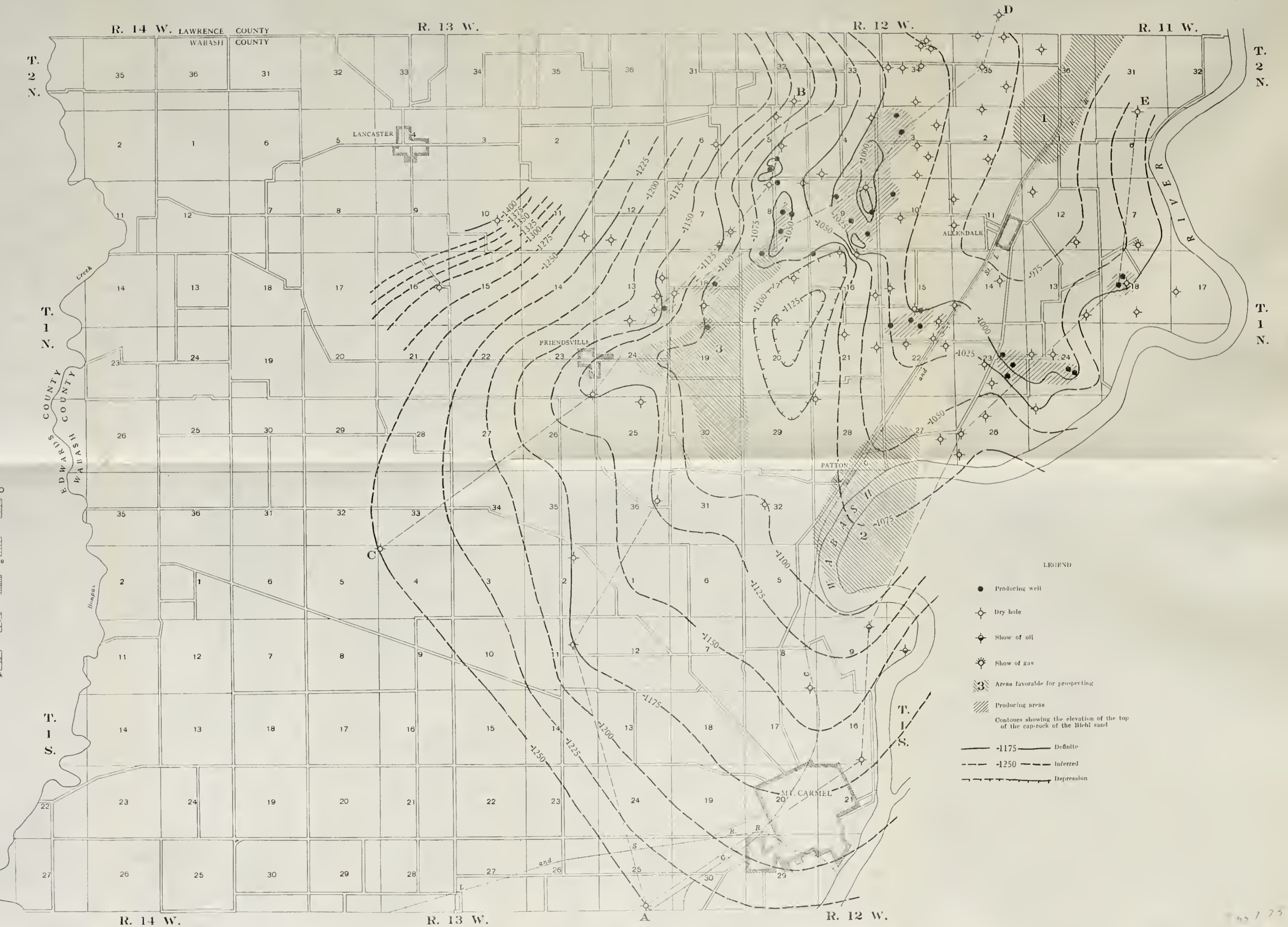
[6] Collingwood, D. M., Extension of the Allendale oil field: Ill. State Geol. Survey Press Bulletin, May 17, 1924.


R. 12 W
FRIENDSVILLE
B
3
-1000
-1025
-1050
-1075
-1100
-1125
-1150
-1175
-1200
-1225
-1250
-1275
-1300
-1325
-1350
-1375
8

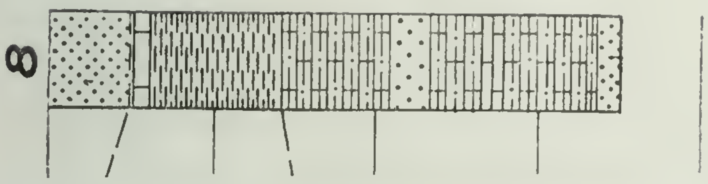


Composite log showing characteristic stratigraphic section in the Allendale area with provisional correlation of the Chester formations.

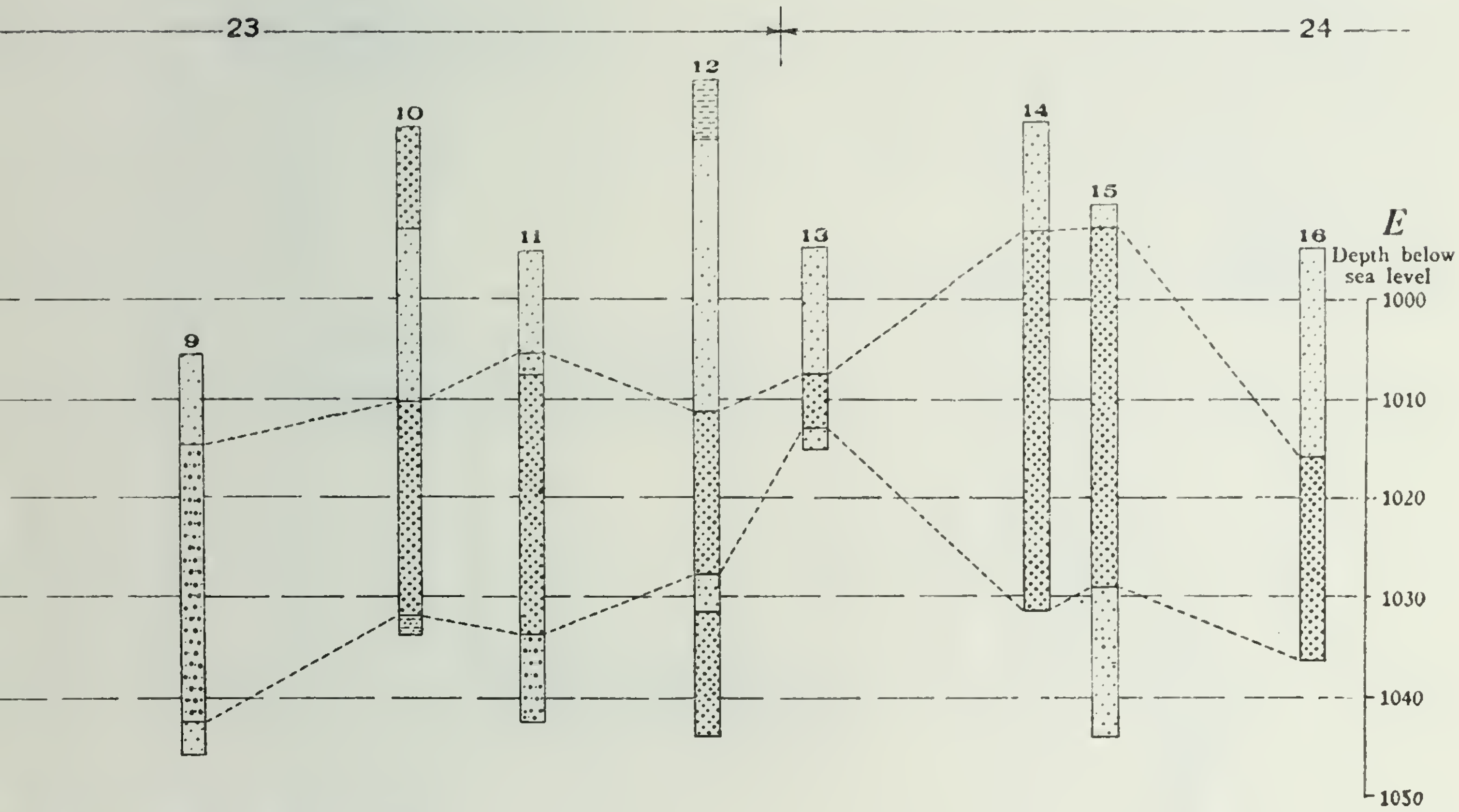


Map of the Allendale area showing structure of the top of the cap-rock of the Biehl sand, locations of some of the holes drilled, producing areas, and areas considered favorable for prospecting.

PLATE IV








tone Shale Silty sandstone

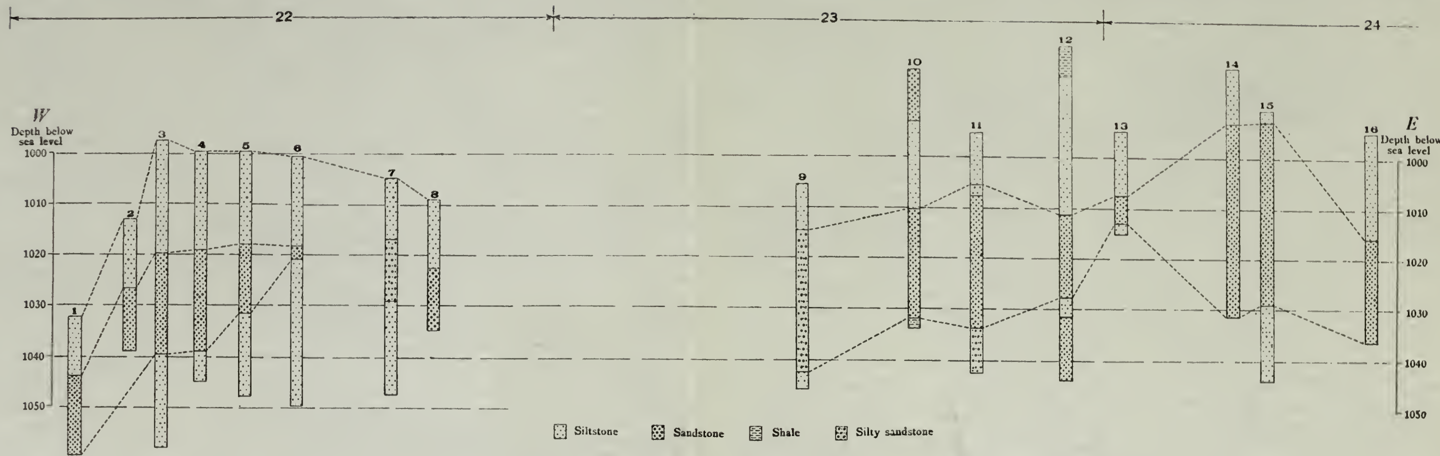
9. Higgens No. 1
   Sec. 23
10. Price No. 1
    Sec. 23
11. Courter No. 3
    NE. ¼ SE. ¼ sec. 23
12. Courter No. 2
    NE. ¼ SE. ¼ sec. 23
13. Clara Armstrong
    SW. cor. NW. ¼ sec. 24
14. C. E. Courter No. 1
    NW. ¼ SW. ¼ sec. 24
15. Winter No. 1
    NE. ¼ SW. ¼ sec. 24
16. H. Armstrong
    NW. ¼ SE. ¼ sec. 24

. 12 W. (Wabash Twp.) showing the variations in sand conditions and structure.



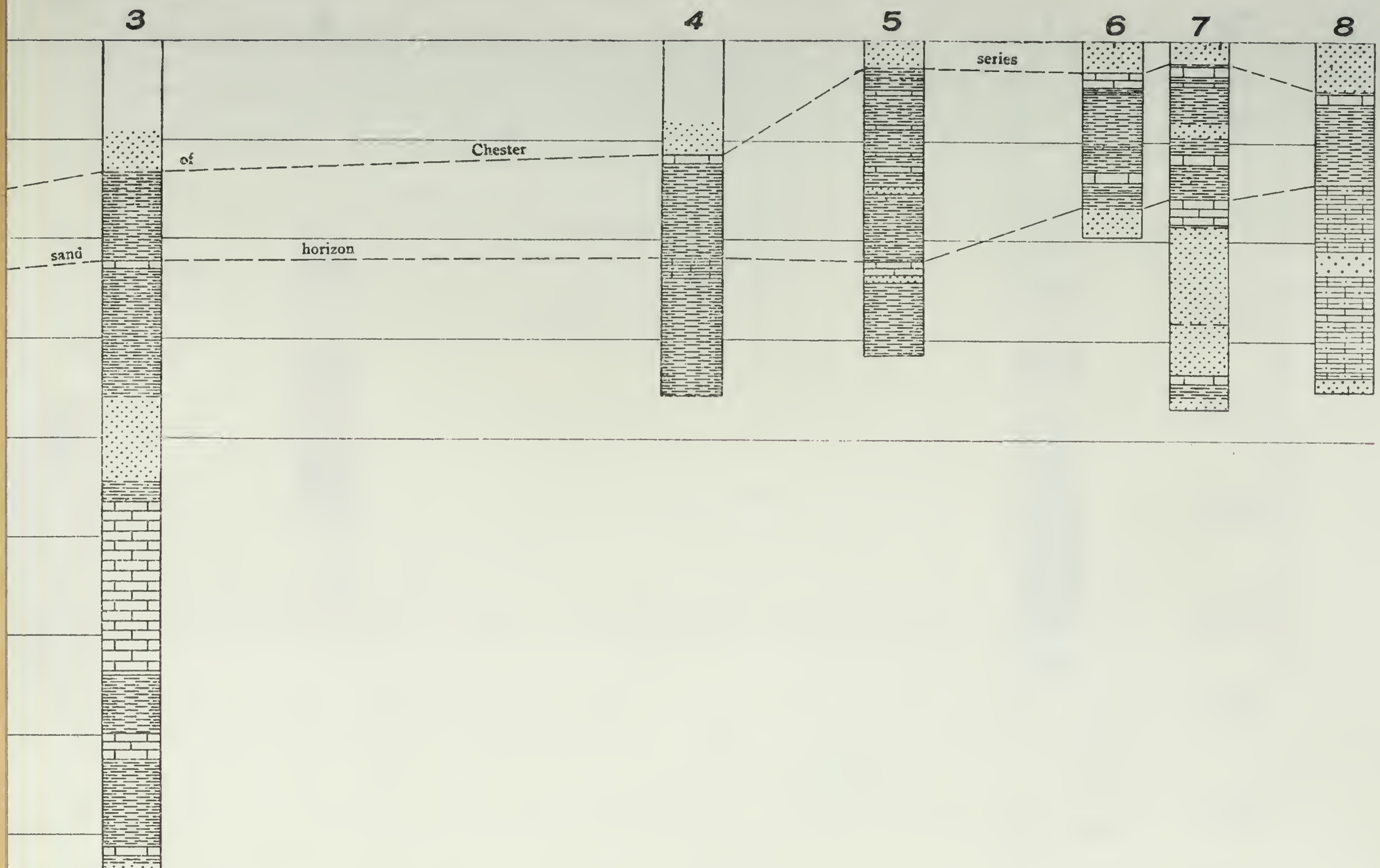
line A-B on Plate I

sand

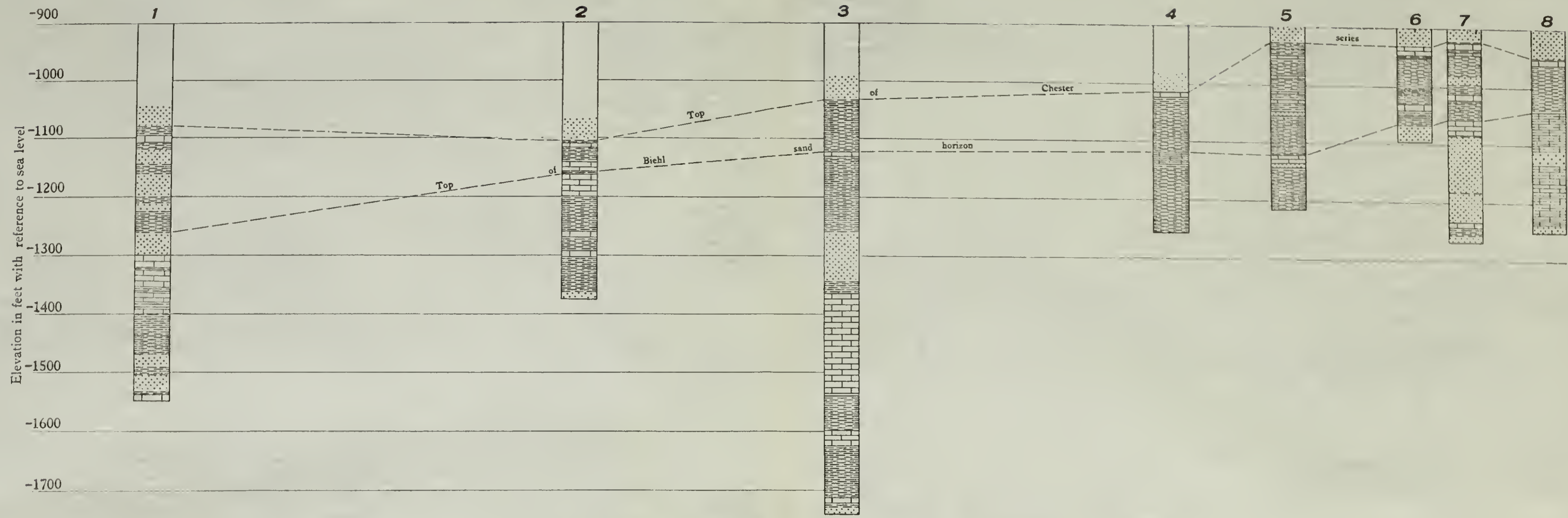



1. J. Smith No. 1
   NW. ¼ NW. ¼ sec. 22
3. J. Smith No.2
   NW. ¼ NW. ¼ sec. 22
3. J. Smith No. 3
   NE. ¼ NW. ¼ sec. 22
4. J. Smith No. 4
   NE. ¼ NW. ¼ sec. 22
5. J. Smith No. 5
   NW. ¼ sec. 22
6. Leek No. 2
   NE. ¼ sec. 22
7. Leek No. 3
   NE. ¼ NW. ¼ NE. ¼ sec. 22
8. Price No. 1
   Sec. 22
9. Higgens No. 1
   Sec. 23
10. Price No. 1
    Sec. 23
11. Courter No. 3
    NE. ¼ SE. ¼ sec. 23
12. Courter No. 2
    NE. ¼ SE. ¼ sec. 23
13. Clara Armstrong
    SW. cor. NW. ¼ sec. 24
14. C. E. Courter No. 1
    NW. ¼ SW. ¼ sec. 24
15. Winter No. 1
    NE. ¼ SW. ¼ sec. 24
16. H. Armstrong
    NW. ¼ SE. ¼ sec. 24

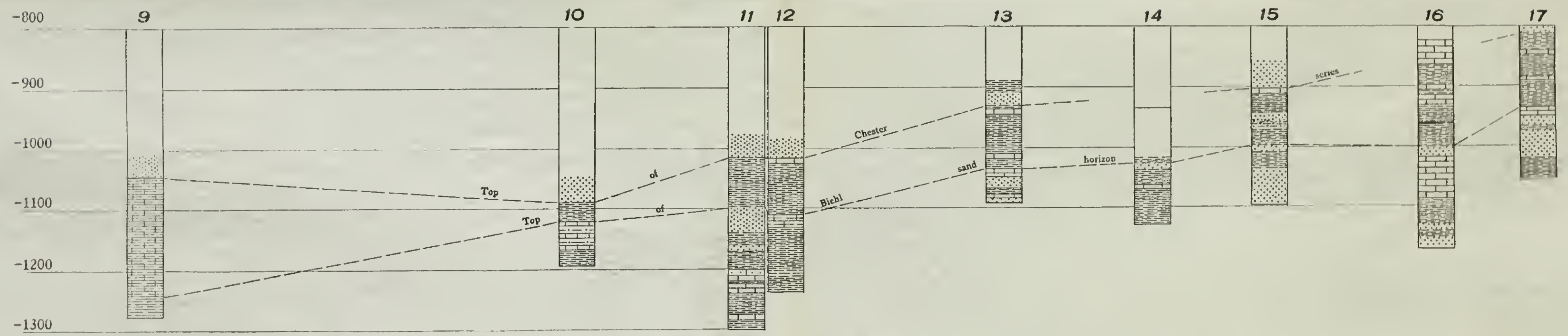
Cross section of the producing zone across secs. 22, 23, and 24, T. 1 N., R. 12 W. (Wabash Twp.) showing the variations in sand conditions and structure.




line A-B on Plate I




**A** Section along line A-B on Plate I

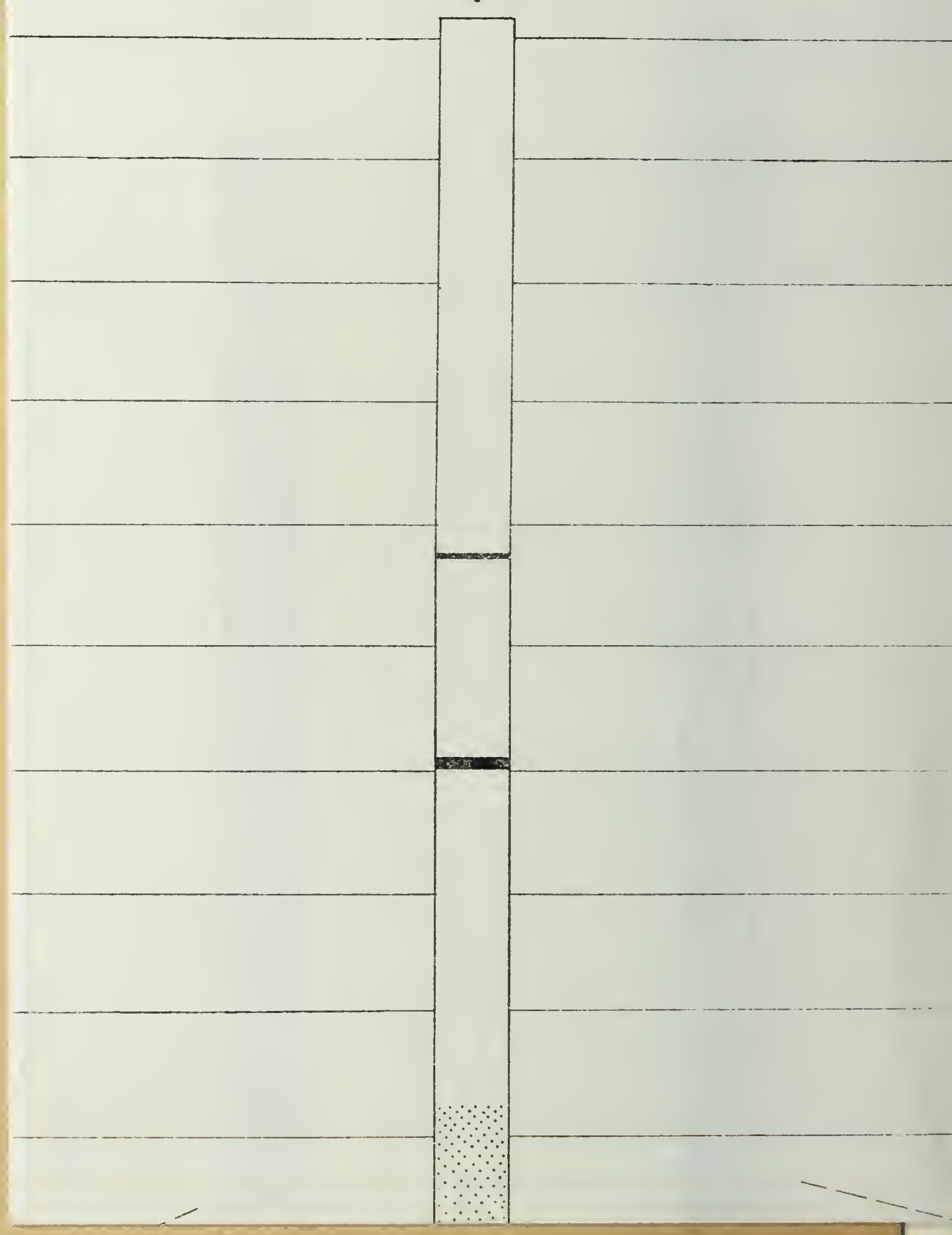


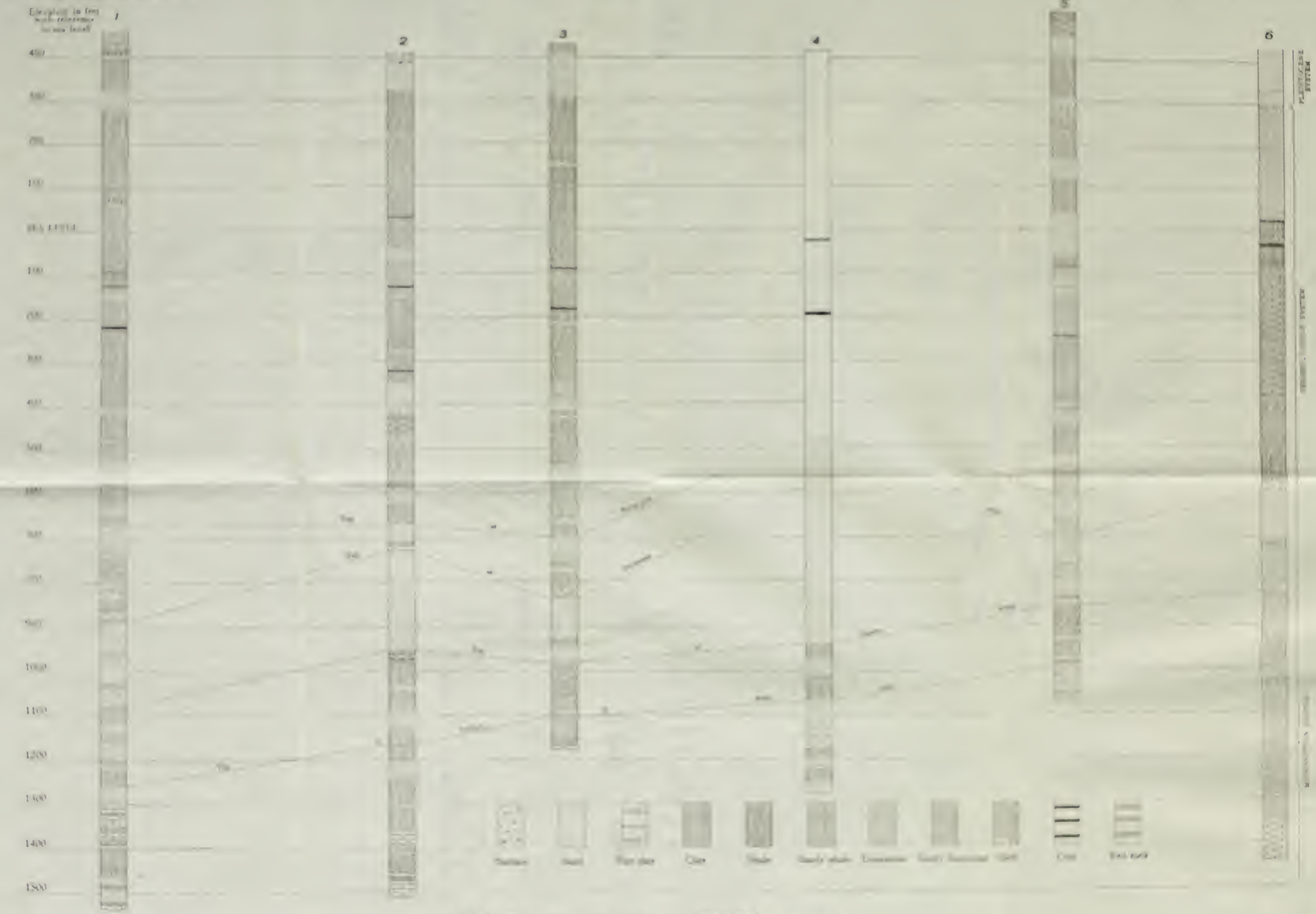

**B** Section along line C-D on Plate I

1. S. G. Reel, No. 1
   SW. ¼ SW. ¼ SE. ¼ sec. 25, T. 1 S., R. 13 W.
2. Ezra Risley
   Center of SW. ¼ NE. ¼ sec. 11, T. 1 S., R. 13 W.
3. Paul Newkirk, No. 1
   SW. cor. SE. ¼ NE. ¼ sec. 36, T. 1 N., R. 13 W.
4. Otis Matheny, No. 2
   NW. cor. SW. ¼ sec. 18, T. 1 N., R. 12 W.
5. E. H. Pixley, No. 1
   SW. cor. SE. ¼ SE. ¼ sec. 7, T. 1 N., R. 12 W.
6. J. L. Lutz, No. 1
   NE. cor. NW. ¼ sec. 8, T. 1 N., R. 12 W.
7. W. J. Schick, No. 1
   SW. cor. NW. ¼ SE. ¼ sec. 5, T. 1 N., R. 12 W.
8. W. A. Andrews, No. 1
   SW. cor. SE. ¼ SE. ¼ sec. 32, T. 2 N., R. 12 W.
9. McGregor, No. 1
   NW. cor. sec. 4, T. 1 S., R. 13 W.
10. Dr. Couch, No. 1
    SE. cor. sec. 23, T. 1 N., R. 13 W.
11. S. A. Zeigler, No. 3
    NW. ¼ SE. ¼ SE. ¼ sec. 13, T. 1 N., R. 13 W.
12. Otis Matheny, No. 2
    NW. ¼ SW. ¼ sec. 18, T. 1 N., R. 12 W.
13. Della Wright, No. 1
    SW. ¼ NW. ¼ SE. ¼ sec. 8, T. 1 N., R. 12 W.
14. Ed Smith, No. 8
    NE. cor. sec. 9, T. 1 N., R. 12 W.
15. Lucy Courter, No. 14
    SE. cor. NW. ¼ SE. ¼ NW. ¼ sec. 3, T. 1 N., R. 12 W.
16. Jim Cogan, No. 1
    SE. cor. NW. ¼ sec. 35, T. 2 N., R. 12 W.
17. Josiah Barthelmy
    SE. cor. NW. ¼ SE. ¼ sec. 26, T. 2 N., R. 12 W.

Sections showing structure and rock changes in Chester beds as determined from borings along the section lines A-B and C-D indicated on Plate I. For legend, see Plate II.

4






Graphic well logs showing structure and changes in the rock section along the line A-B indicated on Plate I.